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(54) Abstract Title: **Decoy for deceiving radar systems**

(57) A decoy for deceiving radar systems, especially Doppler radar systems, comprises a corner reflector, where at least one of its surfaces (1) is arranged to be able to provide a varying reflectivity for radar radiation, especially with a modulation frequency which in the reflected radiation causes Doppler sidebands of an extent that is usual for the radar application. Reflectivity is varied by controlling the switching of an array of diode quads (5) arranged at the junctions (4) of a conducting rectangular grid. (Fig 2 not shown).

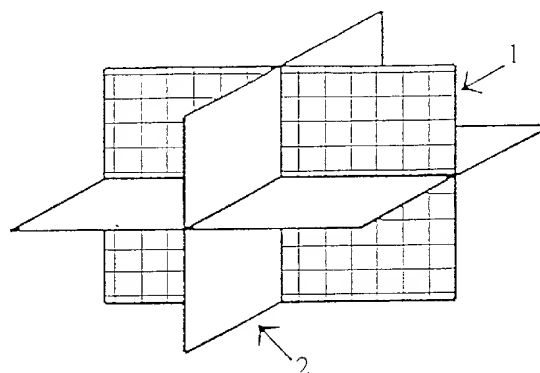


Figure 1

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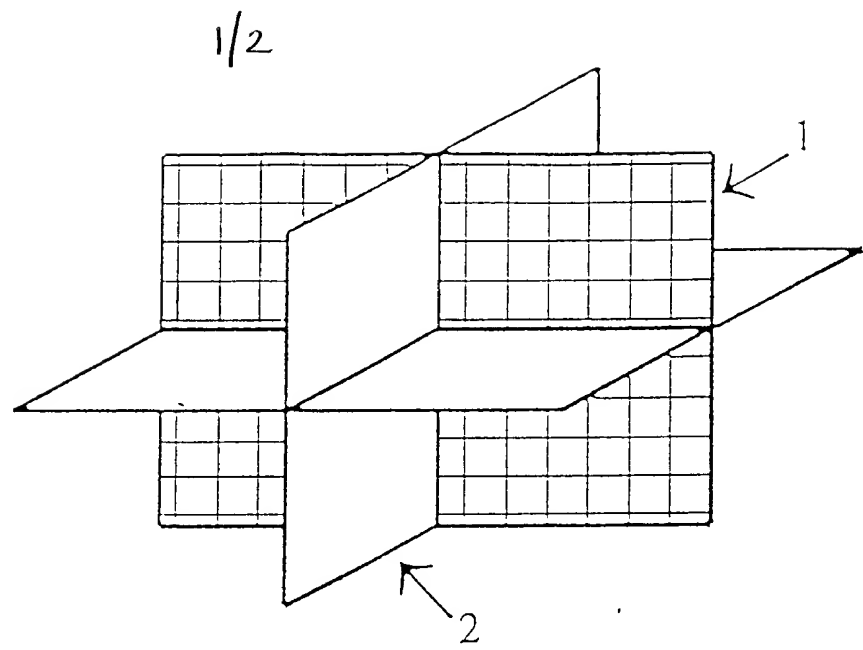


Figure 1

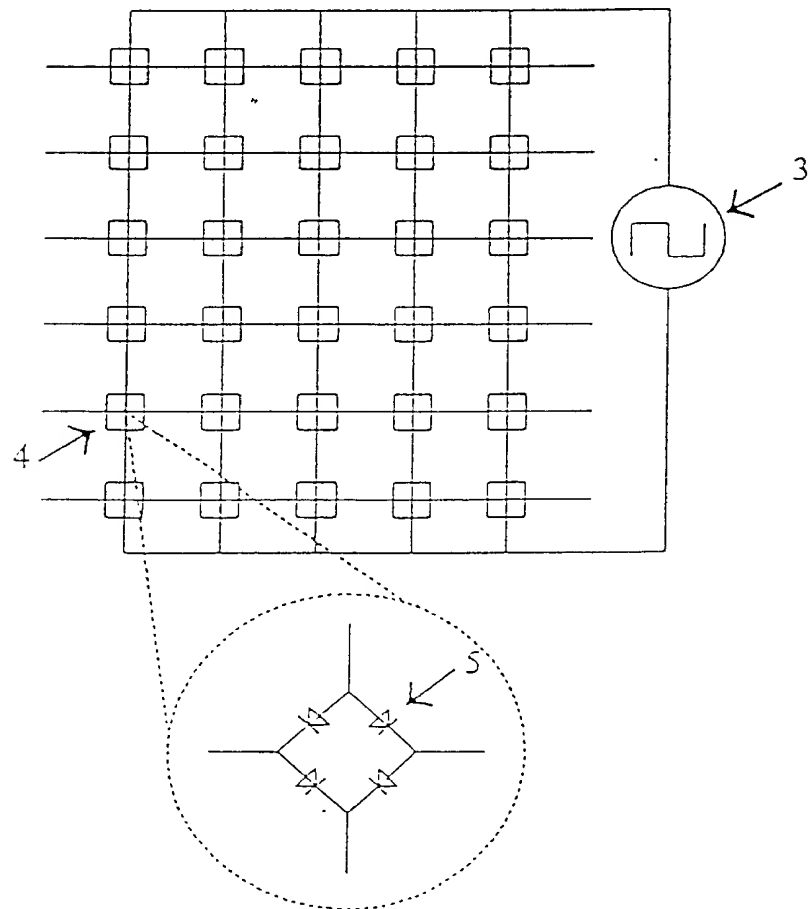


Figure 2

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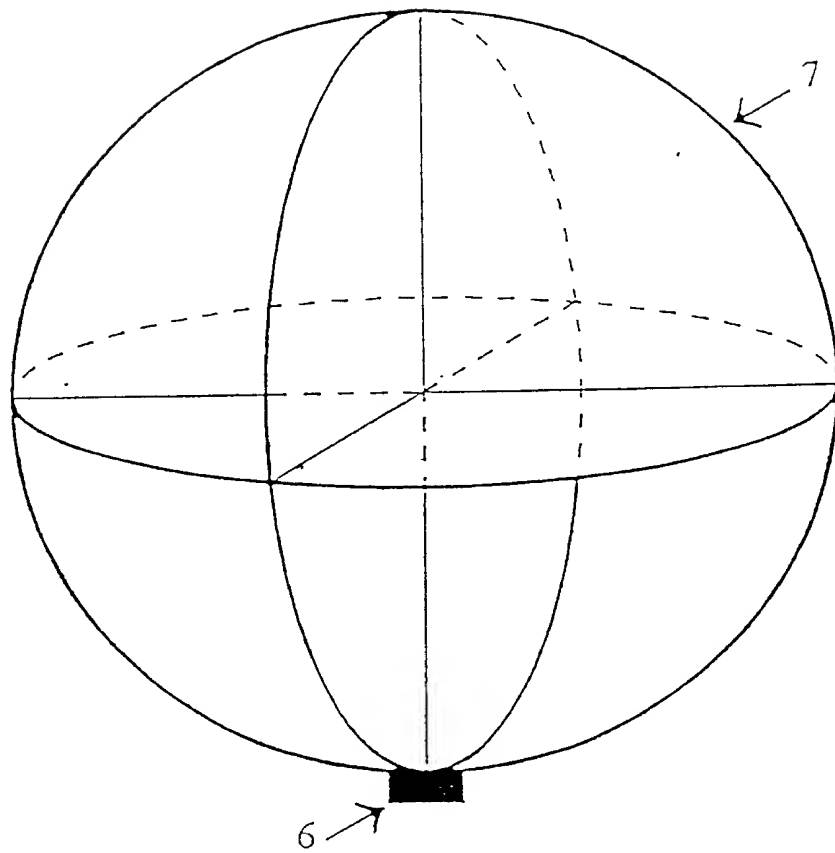


Figure 3

Decoy for deceiving radar systems

The present invention relates to a decoy for deceiving radar systems, especially Doppler radar systems.

Decoys in all forms have constituted and still constitute an important component for deceiving the many sensor systems of war, anything from the eyes of the individual soldier to the ground or air-borne radar system.

Great efforts have been devoted especially to decoys for deceiving radar systems since the object to be protected, in many cases an aircraft, is of considerable military value. Chaff (bundles of strips) has previously been used as decoy for deceiving radar. If the metallised strips are of a length which is suitably adapted to the radar frequency of the radar that is to be misled, a strong resonance is obtained. The strips that are dispersed from aircraft in bundles then cause echoes that can mislead the radar or conceal the aircraft.

The introduction of pulsed Doppler radar dramatically reduced the capability of chaff to influence the radar. A pulsed Doppler radar uses the Doppler effect (phase variation from pulse to pulse in the radar echo) to distinguish reflecting objects moving fast in relation to the radar station and stationary objects. As a result, ground clutter and also chaff that is almost immobile in relation to the ground can be rejected. The use of Doppler radar systems for rejecting ground echoes therefore renders the capability of the bundle of strips of effective misleading impossible.

Other passive methods for confusing radar use reflectors of different kinds, for instance corner reflectors or Luneburger lenses to produce powerful echoes from small objects. To produce the necessary Doppler frequency that permits detection in a Doppler radar, these must then be hauled or accommodated in small decoy aircraft which can separate from the object to be protected. This requires aerodynamically well designed units and, moreover, in many cases restrictions in the flight appearance.

Modern decoy solutions often consist of active jamming transmitters which are launched from the aircraft or hauled thereby. A pure amplification and transmission of the radar pulse cannot be carried out with isotropic

transmitting and receiving antennae owing to insufficient insulation (results in so-called feedback). Other active solutions using e.g. microwave memory and delayed transmission result in distortion of the pulse shape. Narrow band jamming as well as wide band jamming are known. Equipment for jamming by narrow band noise is sensitive to a frequency change of the radar and requires equipment for searching over the frequency band for the new frequency. Wide band noise requires high power output. All in all, active decoys will necessarily be relatively expensive and complicated equipment.

Various aspects of the invention are exemplified by the attached claims. By way of example, one aspect of the invention comprises a decoy for deceiving radar systems, especially Doppler radar systems, the decoy comprising a corner reflector where at least one of the surfaces of the reflector is adapted to be able to obtain a varying reflectivity for radar radiation, especially with a modulation frequency which in the reflected radiation causes Doppler sidebands of an extent that is usual for the radar application.

Such a decoy can be designed as a passive decoy which substantially eliminates all the restrictions that are connected with traditional passive and active decoys. Such a decoy when in the form of a modulated corner reflector can have a combination of properties which is new in the context and which comprises:

- Not filterable in a Doppler radar system,
- reflects any wave form correctly,
- isotropic radiation diagram,
- low power consumption (almost passive)

- size and price at a level allowing launching of showers (5 -10 pieces) at a time (may be regarded as a modern form of Doppler chaff).

These decoys could be usable in different contexts, for instance:

- Launching of decoys for misleading enemy radar missiles, air-borne or ground fire-control radar,

- mass-launching of decoys for masking flight operations against air-borne or ground reconnaissance radar,

placing of decoys on the ground for activation in and thus masking of
low altitude flying operations in prepared corridors,
placing of decoys on the ground close to objects to be protected to render
discovery of these objects by using high-resolution mapping radar
impossible.

For a better understanding of the invention, and to show how the
same may be carried into effect, reference will now be made, by way of
example, to the accompanying drawings, in which:-

Fig. 1 illustrates a corner reflector where one of three surface planes constitutes
a modulatable plane of reflection;

Fig. 2 shows the composition of the modulatable plane of reflection in the form
of a wire structure which has crossing points connected by a diode structure; and
Fig. 3 shows an activated decoy for air-borne application with protective casing
and box for support electronics and battery.

The decoy shown in Fig. 1 comprises a radar-cross-section-modulated
corner reflector having three surfaces, 1 and 2, where two surfaces 2 are
metallised and thus fully reflective. The reflection of the third surface 1 may be
varied, which implies that the total decoy surface is modulated. The
radar-cross-section-modulation will be seen in all directions of incidence except
in parallel incidence with the modulated surface.

Such a radar-cross-section-modulation involves an amplitude modulation
of the pulse train of the radar, which generates symmetric Doppler sidebands on
both sides of the base frequency. The base frequency is the Doppler-shifted
radar frequency. The sidebands are separated by the modulation frequency.

After launching, the decoy will quickly assume wind velocity, and therefore the
Doppler frequency will be low compared with aircraft. The modulation is
carried out as a square wave variation; this implies for all pulsed Doppler radar
systems (LPD, MPD and HPD systems) that a plurality of modulation tones,
above as well as below ground returns, are to be found in the passband active
for the radar. Besides, if the modulation frequency is varied (swept), said tones
will migrate in a natural fashion in the field of analysis of the radar.

A launching situation which is suitable for an aircraft is when turning through the O-Doppler (transverse course relative to lobe direction), since a Doppler radar will then be forced to reject also the target, and the probability of relocking on the decoy is great. By sweeping the modulation frequency, also the probability is increased of penetrating a narrow Doppler filter of the homing type for semiactive radar missile. Besides, the possibility of analyzing and rejection of the decoy based on the measured frequency will be prevented. Therefore, the modulation frequency should suitably be swept in the typical Doppler area close to the 90-degrees-sector position, for instance from 0 to 9 kHz on X-band. The sweeping velocity should correspond to a typical aircraft operation seen in Doppler frequency, for instance 3 kHz/s on X-band.

A further convenient launching procedure involves the increasing of the distance uncertainty of the radar by active noise, whereupon the noise jamming is interrupted at the time of launching, and the radar locks on the decoy.

In contrast to many other repeater jamming systems, reflection against the decoy takes place without the pulse form and the wave form otherwise changing. This implies that radar systems having different wave form techniques (for instance different pulse compression techniques) will receive echo returns which conform with the returns from physical targets. Thus, such echo returns cannot be readily distinguished as false ones.

The controllable surface may consist of lines in a check pattern according to Fig. 2, where each cross 4 in the check pattern is connected by a switching element. The switching element may consist of a diode bridge 5. The diodes can be PIN diodes. When the surface is supplied with a square wave voltage 3 with the modulation frequency, the line pattern will be interconnected and the surface will be reflective with the forward voltage direction. When the voltage reverses, the line pattern will be broken and the surface will assume a significantly lower reflection coefficient.

The diode bridge 5 according to Fig. 2 may consist of four diodes, where the diodes are arranged such that, with forward voltage, current is conducted from the upper arm into the three other arms. In this position, both vertical and

horizontal lines will thus be conducting and the surface as such will be strongly reflecting. With reverse voltage, all diodes however will be reverse-biased and no current will flow in the line pattern. The surface will assume a pattern of dipoles which, if they are shorter than half a wavelength of the incident radar frequency, give the surface its low reflection. It should be noted that this special diode constellation means that the entire surface can be operated by a very simple feeding network that does not interfere with the conductor network for radar-cross-section-modulation.

The decoy can be optimised for various frequency ranges. The following dimensioning can be suitable for X-band:

Distance between switching elements	7 -10 mm,
controllable surface	30 * 30 cm,
number of switching elements	900,
power consumption	< 1.5 W.

This results in a decoy surface corresponding to about 10 m².

Decoys of the type that is intended to be launched from aircraft should be loadable in spaces for standard-type launchers. For this reason, both the two conductive surfaces and the modulating surface can be made of a flexible, foldable material, e.g. a foil-prepared fabric or a line-etched flexible dielectric. To the latter, the diode bridges can be applied by automatic soldering. The surfaces and the support electronics with battery are packed in a box of the size 100 - 200 cm³. On launching, a gas cartridge is activated, which develops a protective casing 7 (Fig. 3 - balloon, cf. air bag) which in turn fixes the reflector planes according to Fig. 3. The support electronics and the battery 6 constitute a stabilising weight, such that the modulating surface 1 after stabilisation is vertical and thus minimises the risk of situations with radar reflection below a low modulation index. The gas cartridge can suitably contain some light inert gas, for example helium, which extends the time of functioning in the air.

The design of decoys for ground use can be made considerably simpler with rigid planes of reflection and a simple plastic cover as a radome. The basic rules for interference action against Doppler radar follow the above description

in all essentials.

Attack and reconnaissance systems which utilise the fact that different ground elements within the main lobe of the antenna get a varying Doppler frequency for Doppler beam sharpening can also be interfered with by the proposed decoy. A random frequency control could then suitably be selected to interfere with the Doppler filtration of the radar. By arranging a number of decoys around ground objects which deserve protection, information on details may be concealed and, consequently, identification and combating can be rendered difficult.

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Claims:

1. A decoy for deceiving radar systems, the decoy comprising a corner reflector having at least one of its surfaces arranged with means able to provide a varying reflectivity for radar radiation.

5 2. A decoy for deceiving radar systems, the decoy comprising a corner reflector having at least one of its surfaces arranged to be able to provide a varying reflectivity for radar radiation, especially with a modulation frequency which in the reflected radiation causes Doppler sidebands of an extent that is usual for the radar application.

10 3. A decoy as claimed in claim 1 or 2, wherein the modulation frequency is variable.

 4. A decoy as claimed in claim 3, wherein the modulation frequency is randomly variable.

15 5. A decoy as claimed in any one of preceding claims, wherein the surface the reflectivity of which can vary comprises a non-reflecting surface provided with a check pattern of conductors arranged so close together that, if they are electrically interconnected at the crossing points, the check pattern reflects incident radar radiation, each crossing point of the check network being provided with switching means for alternately electrically connecting and
20 disconnect the conductors at the crossing point.

 6. A decoy as claimed in claim 5, wherein the switching means comprises four unidirectionally conducting elements in a bridge arrangement for conducting current from one conductor to three other conductors, the check pattern of conductors being arranged so that they can be supplied with a square
25 wave voltage between two opposite sides of the bridge.

 7. A decoy as claimed in any one of the preceding claims, wherein all surfaces are made of a flexible, foldable, material so that the decoy has a storage state in which it is folded before being put into use.

30 8. A decoy as claimed in claim 7, wherein the decoy has permanently reflecting surfaces comprising reflecting foil and the surface or surfaces having a variable reflectivity comprise a line-etched dielectric.

9. A decoy as claimed in claim 7 or 8, and having a flexible closed casing of the balloon type and provided with an inflation device, which in operation transforms it from a storage state to an operative state.

5 10. A decoy as claimed in claim 9, wherein the inflation device is opeable with a light inert gas, such as helium, which gives an extended time of function in its action as an air-borne decoy.

11. A decoy according to any one of the preceding claims in combination with a source of modulation frequency for varying the reflectivity.

10 12. A decoy substantially as hereinbefore described with reference to the accompanying drawings.

Amendments to the claims have been filed as follows

1. A decoy for deceiving Doppler radar systems, the decoy comprising a corner reflector having at least one of its surfaces modified so as to be able to provide a varying reflectivity for radar radiation with a modulation frequency which, in the reflected radiation, causes Doppler sidebands of an extent that is usual for the radar application.

2. A decoy as claimed in claim 1, wherein the modulation frequency is variable.

3. A decoy as claimed in claim 2, wherein the modulation frequency is randomly variable.

4. A decoy as claimed in any one of preceding claims, wherein the surface the reflectivity of which can vary comprises a non-reflecting surface provided with a check pattern of conductors arranged so close together that, if they are electrically interconnected at the crossing points, the check pattern reflects incident radar radiation, each crossing point of the check network being provided with switching means for alternately electrically connecting and disconnect the conductors at the crossing point.

5. A decoy as claimed in claim 4, wherein the switching means comprises four unidirectionally conducting elements in a bridge arrangement for conducting current from one conductor to three other conductors, the check pattern of conductors being arranged so that they can be supplied with a square wave voltage between two opposite sides of the bridge.

6. A decoy as claimed in any one of the preceding claims, wherein all surfaces are made of a flexible, foldable, material so that the decoy has a storage state in which it is folded before being put into use.

7. A decoy as claimed in claim 6, wherein the decoy has permanently reflecting surfaces comprising reflecting foil and the surface or surfaces having a variable reflectivity comprise a line-etched dielectric.

8. A decoy as claimed in claim 6 or 7, and having a flexible closed casing of the balloon type and provided with an inflation device, which in operation transforms it from a storage state to an operative state.

9. A decoy as claimed in claim 8, wherein the inflation device is opeable with a light inert gas, such as helium, which gives an extended time of function in its action as an air-borne decoy.

5 10. A decoy according to any one of the preceding claims in combination with a source of modulation frequency for varying the reflectivity.

11. A decoy substantially as hereinbefore described with reference to the accompanying drawings.



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Claims searched: 1-12

Examiner: John Betts
Date of search: 2 June 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H1Q (QEA, QEC, QEJ) H4D (DSC)

Int Cl (Ed.6): H01Q 15/14 G01S 7/38

Other: On-line: WPI, CLAIMS, INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	US5369408 (USA)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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EUR-CL (EPC): G01S007/38 , H01Q015/18